DOCUMENT RESUME

ED 071 898 SE 015 535

TITLE	Project Physics Tests 4, Light and Electromagnetism.
INSTITUTION	Harvard Univ., Cambridge, Mass. Harvard Project Physics.
SPONS AGENCY	Office of Education (DHEW), Washington, D.C. Bureau of Research.
BUREAU NO	BR-5-1038
PUB DATE	68
CONTRACT	OEC-5-10-058
NOTE	24p.; Authorized Interim Version
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Achievement Tests; *Electricity; Instructional Materials; *Light; Magnets; Multiple Choice Tests; Physics; Secondary Grades; *Secondary School Science; *Tests
IDENTIFIERS	Harvard Project Physics

ABSTRACT

Test items relating to Project Physics Unit 4 are presented in this booklet. Included are 70 multiple-choice and 22 problem-and-essay questions. Concepts of light and electromagnetism are examined on charges, reflection, electrostatic forces, electric potential, speed of light, electromagnetic waves and radiations, Oersted's and Faraday's work, power, transformer, electromagnetic induction, Hertz's experiment, wave interference, light polarization, Michelson and Morley experiment, Newton's theory of colors, Van Allen belts, and relativity. Suggestions are made for time consumption in answering some items. Besides directions and illustrations for explanation use, related physical equations are provided. The work of Harvard Project Physics has been financially supported by: the Carnegie Corporation of New York, the Ford Foundation, the National Science Foundation, the Alfred P. Sloan Foundation, the United States Office of Education, and Harvard University. (CC)

ED 071898

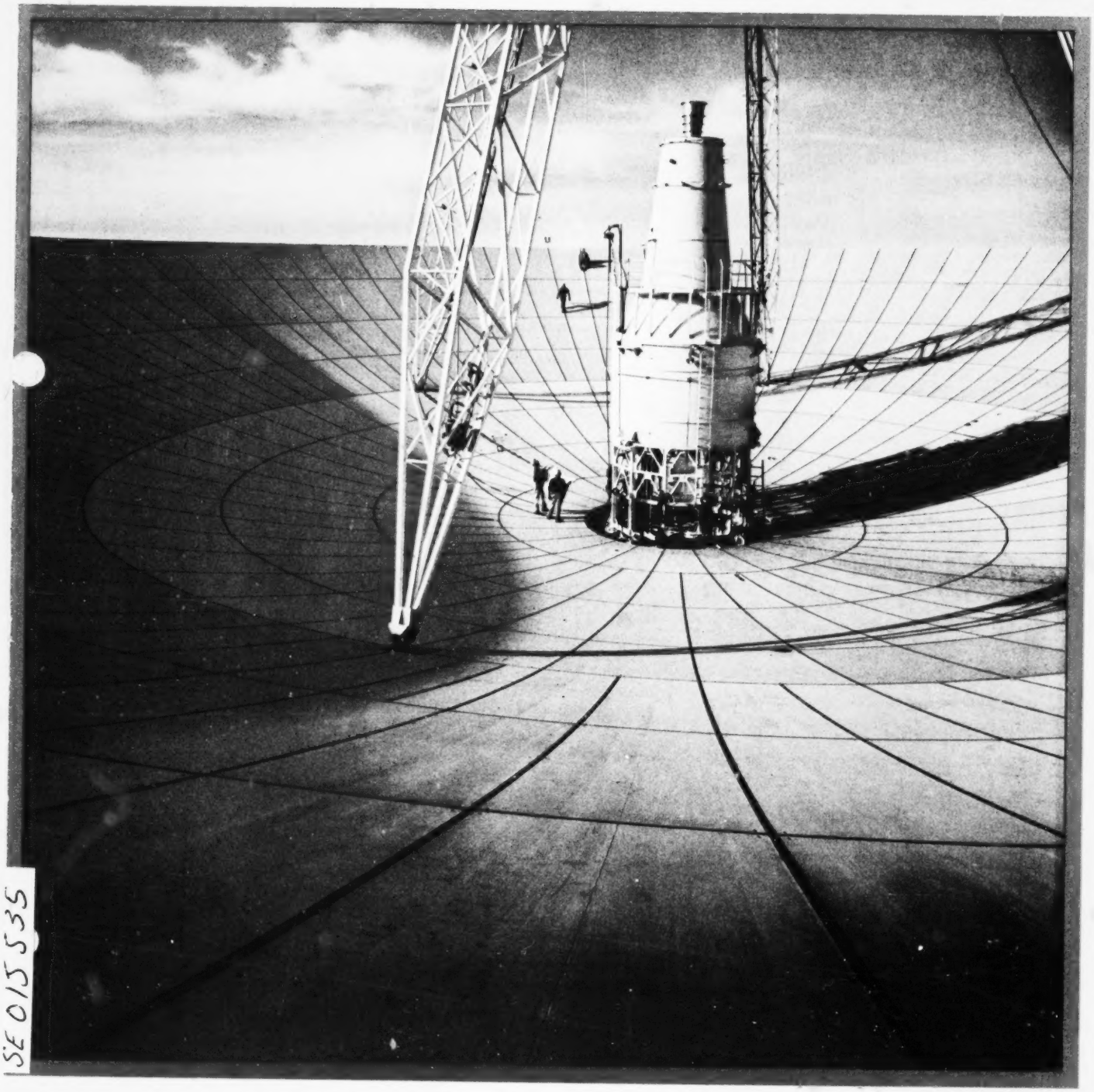
U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY

Project Physics **Tests** 4

Taken From
322 LONGFELLOW

An Introduction to Physics

Light and Electromagnetism



SE 015 535

Cover picture: (Close-up view of the 210 foot-in-diameter tracking and communication antenna, Goldstone, California). Courtesy of Jet Propulsion Laboratory, California Institute of Technology and National Aeronautics and Space Administration.

This test is the authorized interim version of one of the many instructional materials being developed by Harvard Project Physics, including text units laboratory experiments, and teacher guides. Its development has profited from the help of many of the colleagues listed at the front of the text units.

Copyright © 1968, Project Physics Incorporated.

Copyright is claimed until December 31. 1968. After December 31, 1968, all portions of this work not identified herein as the subject of previous copyright shall be in the public domain. The authorized interim version of the Harvard Project Physics course is being distrib uted at cost by Holt, Rinehart and Winston. Inc. by arrangement with Project Physics Incorporated, a non-profit educational organization.

All persons making use of any part of these materials are requested to acknowledge the source and the financial support given to Project Physics by the agencies named below, and to include a statement that the publication of such material is not necessarily endorsed by Harvard Project Physics or any of the authors of this work.

The work of Harvard Project Physics has been financially supported by the Carnegie Corporation of New York, the Ford Foundation, the National Science Foundation, the Alfred P. Sloan Foundation, the United States Office of Education and Harvard University.

Consult the Project Physics text for a partial list of the current and recent staff, consultants and advisory committee.

Authorized Interim Version 1968-69

Distributed by **Holt, Rinehart and Winston, Inc.**
New York, Toronto

1735653

Directions

This test consists of fifteen multiple-choice questions and seven problem-and-essay questions, divided into two groups. Answer ALL multiple-choice questions by marking the letter corresponding to the one best answer. Answer THREE of the problem-and-essay questions from Group One and ONE from Group Two. Spend about 15 minutes on the multiple-choice questions, 5 minutes on each of the problem-and-essay questions from Group One and 10 minutes on the problem-and essay question from Group Two.

NOTE: Equations that may be useful in this test are given below.

Equations:

$$F_{AB} = \frac{kq_Aq_B}{R^2}$$

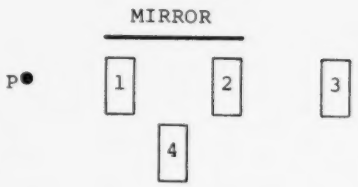
$$v = f\lambda$$

$$P = IV = I^2R$$

$$F = qvB$$

1. A person whose eyes are located at point P is looking into the mirror. Which of the numbered cards can he see reflected in the mirror?

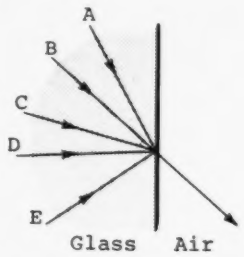
A. 1 and 4
B. 2 and 3
C. 1, 2 and 3
D. 1, 2, 3 and 4



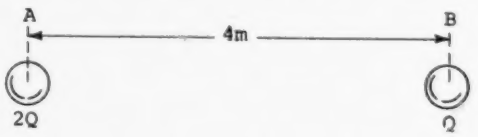
2. A point charge $+Q_1$ exerts an electrostatic force F on point charge $+Q_2$ 3 centimeters away. If the charges are placed 6 centimeters apart, the magnitude of the electrostatic force $+Q_1$ exerts on $+Q_2$ will be

A. 4F
B. 2F
C. F
D. F/2
E. F/4

3. A narrow beam of light emerges from a block of ordinary glass in the direction shown in the diagram. Which arrow in the diagram best represents the path of the beam within the glass?



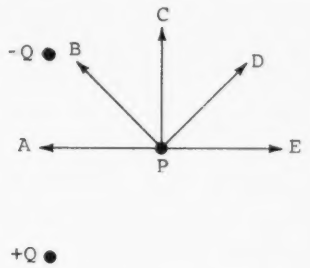
4. Two spheres, A and B, are 4 meters apart. A charge of 2Q coulombs is distributed over sphere A and a charge of Q coulombs is distributed over sphere B. (See sketch.)



How does the magnitude of the force exerted by A on B compare with the magnitude of the force exerted by B on A?

A. The force on A is 4 times the force on B.
B. The force on A is 2 times the force on B.
C. The force on A is the same as the force on B.
D. The force on A is 1/2 the force on B.
E. The force on A is 1/4 the force on B.

5. Which of the arrows indicates the direction of the electric field at point P due to the stationary charges +Q and -Q?



6. The first definite evidence that light moves at a finite speed was found by

A. Galileo.
B. Römer.
C. Huygens.
D. Young.

7. In a vacuum, electromagnetic radiations such as radio waves, light, x rays and gamma rays have the same

A. wave length.
B. frequency.
C. period.
D. speed.
E. amplitude.

8. Newton's synthesis of terrestrial and celestial mechanics incorporated the work of Kepler and Galileo. In a similar way, the work of Oersted and Faraday was incorporated in the synthesis made by

A. Ampère.
B. Hertz.
C. Maxwell.
D. Gilbert.

9. The direction of the electric field in a plane electromagnetic wave is

A. perpendicular to the magnetic field and in the direction of the wave's propagation.
B. perpendicular to the magnetic field and perpendicular to the direction of the wave's propagation.
C. parallel to the magnetic field.

10. Power is

A. work.
B. electrical current.
C. the rate of flow of electric charge.
D. the rate of doing work.

11. A transformer changes

A. electrical energy into mechanical energy.
B. mechanical energy into electrical energy.
C. high voltage dc to low voltage dc.
D. low voltage ac to high voltage ac.

12. An example of electromagnetic induction is the

A. magnetic field about a conductor carrying a current.
B. force between a magnet and a wire carrying a current.
C. production of a current in a wire owing to a changing magnetic field.
D. force between two wires carrying electric currents.
E. depositing of an element at the cathode of an electrolytic cell.

Questions 13, 14 and 15 list the names of scientists who made significant contributions to the study of electromagnetic phenomena. Select the statement that best describes a contribution of each of the scientists.

A. Two current-carrying wires exert forces on each other.
B. An electric field changing with time generates a magnetic field.
C. An electric current exerts a force on a magnet.
D. A magnetic field changing with time can cause a current to flow in a wire.

13. Maxwell

14. Ampère

15. Faraday

TEST A

PROBLEM-AND-ESSAY QUESTIONS

Group One

Answer THREE of the following five questions.

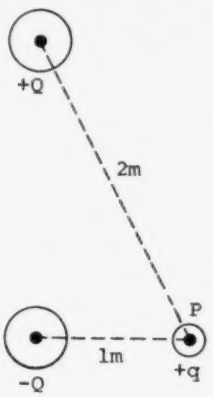
1. Explain how the results of Hertz's experiment supported Maxwell's theory of electromagnetism.

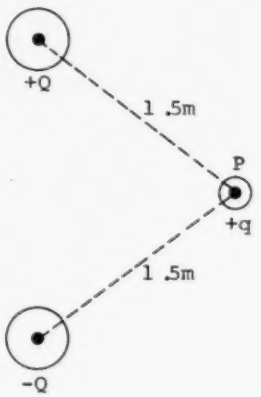
2. What is one of the predictions Maxwell made on the basis of his electromagnetic wave theory?

3. The starter motor in a car for a short time draws a fairly steady current of 100 amperes from a 12-volt battery to turn over the engine. How many watts of power does this represent?

4. Describe two examples of experimental evidence that support the contention that a magnetic field exists in the space around a current-carrying wire.

5. Consider two bodies with charges +Q and -Q, and a third body at P with charge +q, as shown in the diagrams below. In each of the diagrams draw an arrow at P pointing in the direction of the resultant force +q experiences due to +Q and -Q.





PROBLEM-AND-ESSAY QUESTIONS

Group Two

Answer ONE of the following two questions.

6. With the aid of a diagram showing the essential parts of a transformer, explain how a transformer works.

7. Young's double-slit experiment demonstrated the interference of light waves. With the aid of a diagram describe how the experiment is done and explain why interference is observed.

Directions

This test consists of fifteen multiple-choice questions and seven problem-and-essay questions, divided into two groups. Answer ALL multiple-choice questions by marking the letter corresponding to the one best answer. Answer THREE of the problem-and-essay questions from Group One and ONE from Group Two. Spend about 15 minutes on the multiple-choice questions, 5 minutes on each of the problem-and-essay questions from Group One and 10 minutes on the problem-and-essay question from Group Two.

NOTE: Equations that may be useful in this test are given below.

Equations:

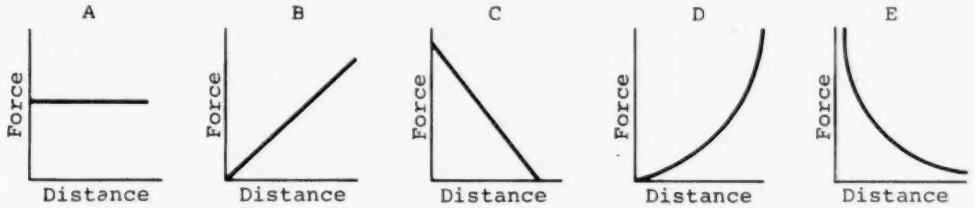
$$F_{AB} = \frac{kq_Aq_B}{R^2}$$

$$v = f\lambda$$

$$P = IV = I^2R$$

$$F = qvB$$

1. Which of the following graphs best represents the way the force one small charged body exerts on another changes when the distance between their centers is changed?



2. ALL EXCEPT ONE of the following satisfy the definition of a field as given in the text. Find the exception.

A. water temperature in Lake Michigan
B. density of smoke in the air above New York
C. noise level in a stadium during a baseball game
D. depth of snow on the ground during a blizzard
E. the total number of babies born in the United States during 1965

3. Which of the following is not an electromagnetic wave phenomenon?

A. radar
B. ultraviolet light
C. sound
D. x-radiation

4. A coulomb is a unit of

A. resistance.
B. power.
C. current.
D. potential difference.
E. charge.

Questions 5, 6 and 7 list the names of scientists who made significant contributions in the study of light. Select the statement from the list below that best describes the contribution of the particular scientist.

A. showed that light exhibits the phenomenon of interference
B. found that color is not an inherent property of an object, but depends on how the object reflects and absorbs the various colored rays that strike it
C. invented a plastic sheet that would polarize light
D. developed a mathematical wave theory of light

5. Young

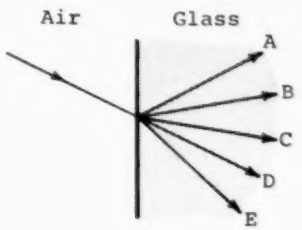
6. Fresnel

7. Newton

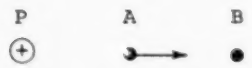
8. In a vacuum, electromagnetic radiations such as radio waves, light, x rays and gamma rays have the same

A. wavelength.
B. frequency.
C. period.
D. speed.
E. amplitude.

9. A narrow beam of light strikes a block of ordinary glass at the angle shown in the diagram. Which arrow in the diagram best represents the direction of the beam within the glass?



Question 10 refers to the following diagram and statement.



A positively charged pith ball is located at point P. The electric field (magnitude and direction) at point A due to the charge at P is represented by the vector shown.

10. Which vector best represents the electric field at point B due to the charge at P?

A. ——————→
B. ————→
C. ——→
D. →
E. →

11. Gravitational and electrostatic (coulomb) forces are similar in many ways but differ in others. Which one of the following statements is not true for both gravitational and electrostatic forces?

A. The force varies as $1/R^2$.
B. The force depends upon the quantity (mass or charge) on which the force acts.
C. The force can be attractive and repulsive.
D. The force law can be tested in the laboratory.

12. The Angstrom ($\mathring{A}$) is a unit of

A. mass.
B. time.
C. speed.
D. length.

13. The direction of the electric field in a plane electromagnetic wave is

A. perpendicular to the magnetic field and in the direction of the wave's propagation.
B. perpendicular to the magnetic field and perpendicular to the direction of the wave's propagation.
C. parallel to the magnetic field.

14. The wavelength of visible light is most nearly the same as

A. the length of a football field.
B. your height.
C. the diameter of an apple.
D. the diameter of a pencil.
E. the thickness of a soap bubble.

15. A conclusion that could be drawn from the experiment of Michelson and Morley was that

A. the speed of light is greater in a vacuum than in glass.
B. light is an electromagnetic radiation.
C. the earth moves through the ether.
D. light consists of particles, not waves.
E. there is no ether.

PROBLEM-AND-ESSAY QUESTIONS

Group One

Answer THREE of the following five questions.

1. The introduction of inexpensively transmitted electrical power late in the nineteenth century had profound effects on the structure of American society. State and discuss briefly two of these effects.

2. Discuss the objection to Newton's theory of color raised by nature philosophers such as Schelling and Goethe.

3. Describe the term "field" as it is used in physics.

4. Describe one property of x rays that makes them suitable for medical diagnosis of bone fractures.

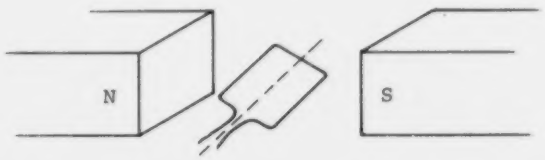
5. State one reason for the conclusion that electromagnetic waves carry energy.

Group Two

Answer ONE of the following two questions.

6. Why is the sky blue?

7. Consider a wire loop between magnetic poles, as shown below. Discuss the physical principles involved when this apparatus is used as a generator of electric current.



Directions

Answer ALL forty multiple-choice questions by marking the letter corresponding to the one best answer.

NOTE: Equations that may be useful in this test are given below

Equations:

$$F_{AB} = \frac{kq_Aq_B}{R^2}$$

$$v = f\lambda$$

$$P = IV = I^2R$$

$$F = qvB$$

1. A unit of electric potential difference is the

A. ampere.
B. ohm.
C. volt.
D. joule.
E. coulomb.

2. Arrange the following units of length in order of increasing magnitude.

1. centimeter
2. angstrom
3. meter

The correct arrangement is

A. 1, 2, 3.
B. 2, 3, 1.
C. 3, 1, 2.
D. 2, 1, 3.
E. 3, 2, 1.

3. The equations that led to the prediction that light is an electromagnetic phenomenon were derived by

A. Coulomb.
B. Oersted.
C. Faraday.
D. Maxwell.
E. Ampère.

4. ALL EXCEPT ONE of the following satisfy the definition of a field as given in the text. Find the exception.

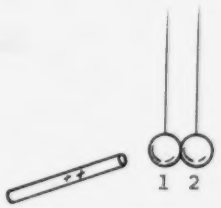
A. water temperature in Lake Michigan
B. density of smoke in the air above New York
C. noise level in a stadium during a baseball game
D. depth of snow on the ground during a blizzard
E. the total number of babies born in the United States during 1965

5. Which one of the following statements is correct?

A. Electricity and magnetism are unrelated phenomena.
B. Magnets can produce electric currents, but electric currents cannot produce magnetic fields.
C. Magnets can produce electric currents and electric currents can produce magnetic fields.
D. Electric currents cannot produce magnetic fields.
E. Electricity and magnetism are identical properties of lodestones.

6. Two uncharged conducting spheres are suspended by nylon threads and touch each other. With a positively charged rod held near sphere 1 the two spheres separate. The charges on the two spheres will be

	Sphere 1	Sphere 2
A.	none	positive
B.	negative	positive
C.	none	none
D.	negative	none



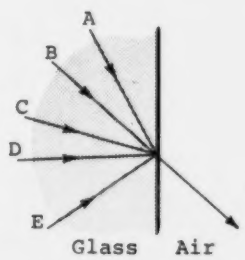
7. The electric field vector at a point in an electrostatic field indicates

1. the magnitude of the electrostatic force exerted per unit charge at that point.
2. the direction of the electrostatic force exerted per unit charge at that point.
3. the electric charge at that point.

Which of the above correctly describe(s) a property of the electric field vector?

A. 3 only
B. 1 and 2 only
C. 1 and 3 only
D. 2 and 3 only
E. 1, 2 and 3

8. A narrow beam of light emerges from a block of ordinary glass in the direction shown in the diagram. Which arrow in the diagram best represents the path of the beam within the glass?



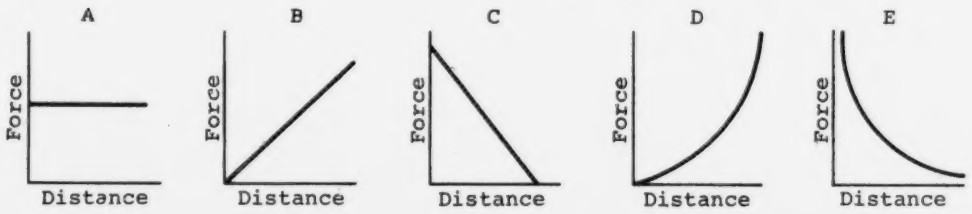
9. Newton's synthesis of terrestrial and celestial mechanics incorporated the work of Kepler and Galileo. In a similar way, the work of Oersted and Faraday was incorporated in the synthesis made by

A. Ampère.
B. Hertz.
C. Maxwell.
D. Gilbert.

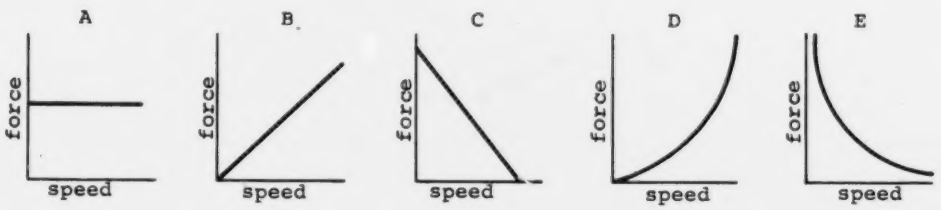
10. A glass prism separates white light into the colors of the spectrum because

A. light is reflected inside the prism.
B. different frequencies of light move with different speeds in the prism.
C. different frequencies of light superpose in the prism.
D. electromagnetic energy is dissipated inside the prism.

11. Which of the following graphs best represents the way the force one small charged body exerts on another changes when the distance between their centers is changed?



12. Which of the following graphs best represents the force on a charged particle moving across a uniform magnetic field when the particle's speed increases?



13. A conclusion drawn from the experiment of Michelson and Morley was that

A. the speed of light is greater in a vacuum than in glass.
B. light is an electromagnetic radiation.
C. the earth moves through the ether with the speed of light.
D. light consists of particles, not waves.
E. there is no ether.

14. Which of the following is not an electromagnetic wave phenomenon?

A. radar
B. ultraviolet light
C. sound
D. x-radiation

15. Which of the following produce(s) a magnetic field?

1. an electric current in a wire
2. a moving charged particle
3. a changing electric field

A. 1 only
B. 1 and 2 only
C. 1 and 3 only
D. 2 and 3 only
E. 1, 2 and 3

16. In a vacuum, electromagnetic radiations, such as radio waves, light, x rays and gamma rays have the same

A. wavelength.
B. frequency.
C. period.
D. speed.
E. amplitude.

17. P watts of power are dissipated in the form of heat when a current I flows through a heater coil whose resistance is R. If the current through the coil is doubled, how much power will be dissipated in the form of heat?

A. 1/4 P watts
B. 1/2 P watts
C. P watts
D. 2P watts
E. 4P watts

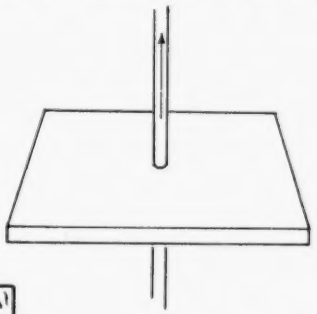
18. Gravitational and electrostatic (Coulomb) forces are similar in many ways but differ in others. Which one of the following statements is not true for both gravitational and electrostatic forces?

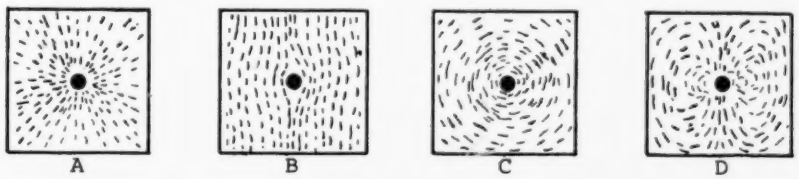
A. The force varies as $1/R^2$.
B. The force depends upon the quantity (mass or charge) on which the force acts.
C. The force can be attractive and repulsive.
D. The force law can be tested in the laboratory.

19. The direction of the electric field in a plane electromagnetic wave is

A. perpendicular to the magnetic field and perpendicular to the direction of the wave's propagation.
B. perpendicular to the magnetic field and in the direction of the wave's propagation.
C. parallel to the magnetic field.

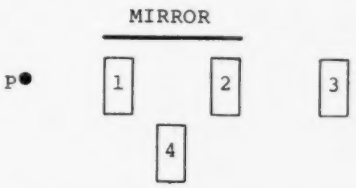
20. A wire carrying a large and constant electric current passes through the center of and perpendicular to a piece of cardboard, as shown at right. If iron filings are sprinkled on the cardboard, how will they arrange themselves?





21. A person whose eyes are located at point P is looking into the mirror. Which of the numbered cards can he see reflected in the mirror?

A. 1 and 4
B. 2 and 3
C. 1, 2 and 3
D. 1, 2, 3 and 4



22. The wave and particle models of light predict contradictory values of the velocity of light when used to explain

A. relection of light.
B. refraction of light.

23. Consider the following:

1. a wire loop surrounding a wire with a steady current.
2. a magnet dropping through a wire loop.
3. a stationary charged sphere at the center of a wire loop.

In which of the above is a current produced in the wire loop?

A. 1 only
B. 2 only
C. 3 only
D. 1 and 3 only
E. 2 and 3 only

24. Which of the following is the chief physical principle on which the operation of an electric generator depends?

A. A current is induced in a wire moving through a magnetic field.
B. The electric field strength varies as the inverse square of the distance from a charge.
C. Two current-carrying wires exert forces on one another.
D. An alternating current produces electromagnetic radiation.

25. The Angstrom ($\mathring{A}$) is a unit of

A. mass.
B. time.
C. speed.
D. length.

26. Which of the following could you measure to find your true motion through space?

A. apparent speed of light
B. speed of the motion relative to the ether
C. speed of the motion relative to some stationary object
D. none of the above

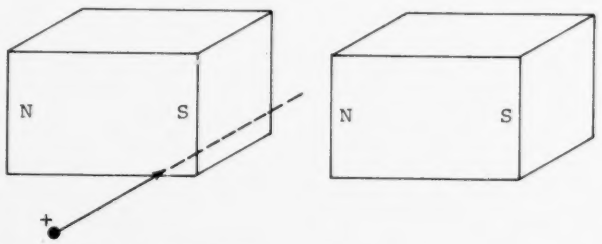
27. A vertical wire hidden in a wall is carrying a direct current. What piece of equipment might help you find the location of the wire?

A. transformer
B. dc generator
C. compass
D. radio receiver

28. Two identically charged small spheres are at a distance r meters apart. If the distance is doubled to 2r meters, the force exerted on each sphere will

A. change to 4 times the original value.
B. change to 2 times the original value.
C. not change.
D. change to 1/2 the original value.
E. change to 1/4 the original value.

29. In the apparatus shown at right, a beam of positively charged particles is directed horizontally into the field between two magnets. What is the effect of the magnetic field?



A. The particles continue in the same direction with the same speed.
B. The particles are accelerated toward the S magnetic pole.
C. The particles are accelerated toward the N magnetic pole.
D. The particles are accelerated upward.

Questions 30, 31 and 32 list the names of scientists who made significant contributions in the study of light. Select the statement from the list below that best describes the contribution of the particular scientist.

A. Light exhibits the phenomenon of interference.
B. Color is not an inherent property of an object, but depends on how the object reflects and absorbs the various colored rays that strike it.
C. Invented a plastic sheet that would polarize light.
D. Developed a mathematical wave theory of light.

30. Young

31. Fresnel

32. Newton

33. Three identical metal balls A, B and C are mounted on insulating rods. Ball A has a charge +q, while balls B and C are uncharged. Ball A is brought into contact momentarily with ball B, and then with ball C. At the end of this experiment, the charge on ball A will be:

A. +q.
B. +q/2.
C. +q/3.
D. +q/4.
E. No charge remains on A.

Questions 34, 35 and 36 list the names of scientists who made significant contributions to the study of electromagnetic phenomena. Select the statement that best describes a contribution of the particular scientist.

A. Two current-carrying wires exert forces on each other.
B. An electric field changing with time generates a magnetic field.
C. An electric current exerts a force on a magnet.
D. A magnetic field changing with time can cause a current to flow in a wire.

34. Maxwell

35. Ampère

36. Faraday

37. An electric motor that draws a two-ampere current when operating at 110 volts can do work at the rate of

A. 55 watts.
B. 110 watts.
C. 220 watts.
D. 440 watts.

38. Which one of the following scientists first demonstrated experimentally that the earth behaves like a large magnet?

A. Gilbert
B. Oersted
C. Faraday
D. Maxwell
E. Ampère

39. A charged particle moves through a uniform magnetic field. The effect of the field can change the particle's

A. velocity.
B. speed.
C. energy.

40. A transformer can be used to change

A. electrical energy into mechanical energy.
B. mechanical energy into electrical energy.
C. high voltage dc to low voltage dc.
D. low voltage ac to high voltage ac.

Directions

This test consists of eight questions in two groups. Answer only FOUR of the five questions in Group One, and only TWO of the three questions in Group Two. Spend about 5 minutes on each of the questions from Group One, and 10 minutes on each of the questions from Group Two.

NOTE: Equations that may be useful in this test are given below.

Equations:

$$F_{AB} = \frac{kq_Aq_B}{R^2}$$

$$v = f\lambda$$

$$P = IV = I^2R$$

$$F = qvB$$

Group One

Answer only FOUR of the five questions in this group.

1. Describe any changes that occur in the velocity, wavelength, and frequency of light as it passes from air into a block of glass.

2. Explain why there are belts of rapidly moving charged particles (Van Allen belts) around the earth.

3. Was the postulation of an ether a necessary part of Maxwell's electromagnetic theory? Explain briefly.

4. Describe two similarities between x rays and radio waves.

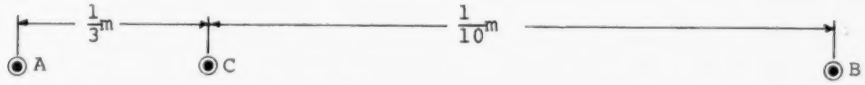
5. Describe how to determine whether a given material is an electrical insulator or conductor.

Group Two

Answer only TWO of the three questions in this group.

6. Three charged objects A, B and C are situated as indicated in the diagram below. Use Coulomb's law to calculate the net electrostatic force on C.

$\left(k = 9 \times 10^9 \frac{Nm^2}{coulomb^2}\right)$



$q_A = +1 \times 10^{-6} C$ $q_C = -1 \times 10^{-6} C$ $q_B = +2 \times 10^{-6} C$

7. Why are brilliantly colored sunsets sometimes seen in highly industrial areas where there is the problem of air pollution?

8. What are the two main assumptions of Einstein's special theory of relativity?